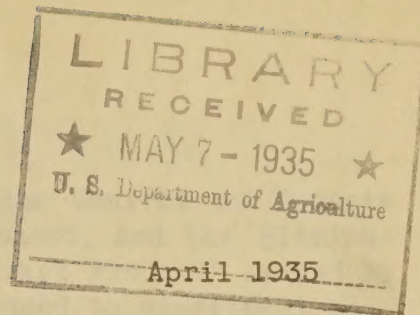


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RECOMMENDATIONS FOR THE CONTROL OF INSECTS ATTACKING CERTAIN
VEGETABLES, SMALL FRUITS, AND TOBACCO, AND THE ELIMINATION
OF HARMFUL INSECTICIDAL RESIDUES FROM THE MARKET PRODUCT

Issued by the Bureau of Entomology and Plant Quarantine,
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Introduction

This supersedes the "Memorandum Regarding the Control of Insects Attacking Certain Vegetables, Small Fruits, and Tobacco, and the Elimination of Harmful Insecticidal Residues from the Market Product" issued by the Bureau under date of March 14, 1934, and addressed to experiment station and State entomologists. The developments of the 1934 season at the various laboratories of this Bureau have made desirable certain changes in the recommendations issued last year.

Location of work

This Bureau's researches on methods of control, having for their object the elimination of harmful insecticidal residues, are being conducted at the following laboratories: Chadbourn, N. C., Charleston, S. C., Sanford, Fla., Baton Rouge, La., Columbus, Ohio, Clarksville, Tenn., Quincy, Fla., Alhambra, Calif., and Biloxi, Miss.

Materials tested

The recommendations included in this circular are based principally upon tests with the following insecticides: Dusts: Commercially prepared or home-mixed derris root powder, pyrethrum powder, cryolite (natural and synthetic), used with various diluents, paris green diluted with hydrated lime, commercial calcium arsenate in the undiluted form and diluted with sulphur. Sprays: Derris root powder in water, commercially prepared extracts of derris and of pyrethrum and combinations of these materials, cryolite (natural and synthetic), and magnesium arsenate.

Principal insects involved

The principal pests involved in these tests are the cabbage worms, celery leaf tier, bean beetle, pepper weevil, vegetable weevil, melon worm, pickle worm, strawberry weevil, tobacco hornworm, and flea beetles.

Recommendations for Control

The following recommendations are applicable only to certain crops on which harmful insecticidal residues may occur on the marketed product. The measures here outlined for the control of insects attacking such crops are the best methods available that can be recommended and that will reduce to a minimum or eliminate residues from treatments with arsenic or similar poisonous insecticides.

The use of lead arsenate is not recommended for the control of insects attacking any vegetable crop considered in this circular.

The use of other arsenicals and cryolite is, however, suggested as a control for certain insects on several of the crops under consideration. This suggestion is made with the provision that the poison should not be used after the appearance on the plant of fruit or foliage which will be sent to market or consumed, except in cases where it is definitely known that washing or stripping will remove all spray residues.

In the interests of the vegetable industry, it is strongly urged that the growers be warned of the poisonous nature of arsenicals and similar materials and that they take special precautions to be certain that none of these materials remain on the marketed product.

From the evidence at hand, the compounds of derris and pyrethrum, when applied at the dosages recommended herein, should not leave harmful residues on the market product. The active principles of these materials are rendered inert within a comparatively short time through the action of sunlight and exposure to the air, especially when spread thinly over the plants.

Cabbage Worms on Cabbage

As a general recommendation for the control of the imported cabbage worm, cabbage looper, and diamond-back moth on cabbage, the following materials (as dusts) are recommended in the order listed, at the dosages detailed later in this circular.

Materials for dusts

- (1) Derris.
- (2) Pyrethrum.
- (3) Paris green, cryolite, calcium arsenate.

The dusts containing these materials should be applied in such a manner as to cover all infested portions of the plant, care being taken to reach the insects whenever possible. The rate of application may vary according to the size of the plants. Applications of 15 to 20 pounds per acre, per application, of the dust mixtures discussed later have given satisfactory results. Applications should be made in accordance with the more specific recommendations that follow; they should begin when the worms first appear and be repeated as often as necessary to protect the crop.

NOTE: Paris green, cryolite, and calcium arsenate should not be used on any portion of the cabbage plant that is to be marketed. This means that cabbage intended for marketing as U. S. Grade No. 1 (which allows four loose outer leaves) should not be poisoned with these materials after the head begins to form. If the marketed product is to bear a greater number of loose outer leaves than those allowed in the above grade, these materials should not be used at any time.

Materials for sprays

In general, dusts have given better results than sprays in cabbage worm control. If desirable to use a spray, the following materials are recommended. Experiments to date have not indicated any special preference for either of these spray materials on the basis of their effectiveness.

- (1) Derris root powder in water.
- (2) Pyrethrum extract, or pyrethrum-derris extract combined.

Relative effectiveness of dusts to specific cabbage insects

Based upon the relative efficiency, at the dosages recommended herein, of each of the insecticides tested, against each of the principal species of cabbage worms present, our experiments indicate: (1) That as a control for the imported cabbage worm, derris was more effective than pyrethrum, paris green, cryolite, or calcium arsenate, while pyrethrum was superior to the last three materials; (2) that derris and pyrethrum were approximately equal in effectiveness in controlling the cabbage looper, and both materials were more effective than paris green, cryolite, or calcium arsenate; (3) that derris and calcium arsenate were approximately equal in effectiveness in controlling the larvae of the diamond-back moth, while pyrethrum, cryolite, and paris green were relatively less effective for this species.

Derris and pyrethrum, in the dilutions used, have not been effective against cutworms, the corn earworm (tomato fruitworm), the zebra caterpillar, or tobacco hornworms.

Derris

Derris dusts. - Derris dusts containing 0.5 to 1.0 percent of rotenone have given very promising results in four sections of the Central, Eastern, and Southern States. Satisfactory diluents for the derris root powder are such nonalkaline materials as finely ground tobacco dust, finely ground clay, talc, diatomaceous earth, infusorial earth, and sulphur. Some of these diluents have the advantage of being more economical in cost and more readily available in some sections of the country than in others. Indications are that derris retains its insecticidal value for a period of only approximately one week in the field, under favorable weather conditions, although further work must be done before definite conclusions can be reached upon this point. Satisfactory results were obtained with commercial dusts containing approximately 0.5 percent of rotenone.

The rotenone content of derris root varies, and purchases should be made on the basis of rotenone content, total extractives, and degree of fineness. For example, a derris root powder containing 4 percent rotenone should contain not less than 14 percent total carbon-tetrachloride or ether extractives. In general, the total extract (either by carbon tetrachloride or ether) should average approximately three and one-half times the rotenone content. The derris root powder should be of such a degree of fineness that not less than 90 percent of it will pass through a sieve having 200 meshes per linear inch, and all of the material (100 percent) should pass through a sieve having 80 meshes per linear inch.

The rotenone content of the finished mixed dust depends, of course, on the amount of diluent used as well as on the amount of rotenone in the original material. Insecticide companies now sell high-grade, finely ground derris powder of specified rotenone content made by blending the various analyzed batches.

To prepare a dust containing 1 percent of rotenone, use the following formula:

Derris powder (4 percent rotenone)	25 lbs. (1 part by weight)
Diluent	75 lbs. (3 parts by weight)

To prepare a dust containing 0.5 percent of rotenone, use the following formula:

Derris powder (4 percent rotenone)	12½ lbs. (1 part by weight)
Diluent	87½ lbs. (7 parts by weight)

If the rotenone content of the derris powder is greater or less than 4 percent, the proportions of inert diluent must be varied accordingly. For example, a derris powder containing 5 percent of rotenone should be mixed with four parts of the diluent by weight, that is, 20 pounds of the derris powder containing 5 percent of rotenone and 80 pounds of the diluent, to obtain a 1-percent rotenone dust.

Derris dusts have also given an indication that they may aid in the control of certain aphids as well as thrips and flea beetles which infest cabbage and related crops.

Derris sprays.— Good control has been obtained with derris root powder (containing 4 percent of rotenone) in water at the rate of 2 to 2½ pounds per 50 gallons of water, giving a rotenone content in the spray ranging from 0.02 to 0.025 percent. If the rotenone content of the derris powder is greater or less than 4 percent, the amount of the powder used should be varied accordingly in order to give the above indicated strengths of 0.02 to 0.025 percent rotenone content in the spray. For example, if the derris root powder contains 5.5 percent rotenone, 1½ pounds of the powder should be used to give the desired content in the spray. Under some conditions it may be necessary to add a nonalkaline spreader or sticker to the spray, such as high-grade liquid or powdered neutral coconut oil soap, miscible pine oil, or one of the sulphonated oils.

Pyrethrum

Pyrethrum dusts.— Pure fresh pyrethrum dust, containing approximately 0.9 percent total pyrethrins, diluted with 5 parts of the same diluents, by weight, as recommended for use with derris dust, have shown promising results. For the most effective results it is essential that applications of this material should be made in the late afternoon or early evening.

Pyrethrum sprays.— Fairly satisfactory results have been obtained by the use of commercial pyrethrum extracts. These extracts vary as to their pyrethrin content. The directions given by the manufacturer should be used as a basis for the dilution of these materials.

Pyrethrum-derris extracts in combination

Fairly satisfactory results have been obtained with commercially prepared extracts of pyrethrum and derris in combination. The directions given by the manufacturer should be used as a basis for the dilution of these materials.

Paris green dusts

Results indicate that paris green is more effective as a dust than as a spray when used at a dilution of 1 pound to 9 pounds of hydrated lime, applied at a rate of 20 pounds per acre, per application, until the plant begins to head, provided the headed cabbage is stripped to four loose outer or wrapper leaves when being prepared for market. If the marketed product is to bear a greater number of loose outer leaves than those allowed in the above grade, paris green should not be used at any time.

Cryolite (sodium fluoaluminate) dusts

Both synthetic and natural cryolite prepared for insecticidal purposes have given favorable results when mixed with from 1 to 3 parts of the diluents mentioned for derris dusts. The same care should be exercised to avoid harmful residues from cryolite as has been prescribed for arsenicals.

Calcium arsenate dusts

Results with commercial calcium arsenate, for cabbage worm control, have shown a variation in the toxicity of various brands of this arsenical. Calcium arsenate, in the undiluted form, gave fairly satisfactory results when applied at the rate of 15 to 20 pounds per acre per application. On account of the harmful residue hazard, this material is subject to the same limitations mentioned for paris green and cryolite.

Cabbage Worms on Cauliflower, Broccoli, Kale, and Collards

The Bureau has not yet had an opportunity to conduct any extensive experiments on the control of cabbage worms on cauliflower, broccoli, kale, or collards. In general, it is believed that the derris and pyrethrum compounds should give the same results on these crops as when used on cabbage, provided a good coverage of the affected parts of the plant can be obtained.

The 1934 experiments on collards indicate that each of the three more common species of cabbage worms may be controlled satisfactorily with a derris dust mixture containing 0.5 percent of rotenone. Less satisfactory results were obtained with pyrethrum powder containing 0.9 percent total pyrethrins, diluted with 5 parts of the same materials as mentioned for derris dust. It should be emphasized that arsenicals are not recommended for cabbage worm control on these crops, owing to the poisonous residues likely to remain on the edible portion, and because less satisfactory results were obtained with arsenicals.

Celery Insects

Celery leaf tier. - The celery leaf tier is the major pest of celery in the Florida producing area, and also periodically becomes troublesome in the North and in California. This pest can be controlled by careful treatments with pyrethrum dust, the dust being mixed with an equal quantity by volume of tobacco dust. The treatment consists of making two applications within a period of one-half hour. The object of making the second treatment within such a period is to kill those worms which have moved from the web as a result of the first treatment. Approximately 25 pounds of the mixture per acre are necessary for each application. Except under unusual conditions in the Florida area, one treatment, that is, two applications at a half-hour interval, is sufficient to protect any one given area of celery.

Arsenicals are not satisfactory as a control for this pest and are not recommended.

Celery looper. - Several species of loopers attack celery. In Florida these pests are usually held in check by a bacterial disease, and observations so far would indicate that ordinarily no artificial control measures are necessary. These pests succumb readily to treatments of pyrethrum powder as recommended for the celery leaf tier, and arsenical applications are not necessary.

Cutworms. - The use of a poisoned bait is the only practicable means for the control of the majority of the species of cutworms attacking celery. The risk from poison residue can be eliminated by distributing one of the standard cutworm baits between the rows, provided care is taken to keep the bait from falling on the plants.

Cultural practice. - Under Florida conditions, the cleaning up of the crop refuse after harvest is valuable in pest control, particularly of the celery leaf tier.

Lettuce and Spinach Insects

There are several leaf-feeding forms which may attack lettuce and spinach, and on occasions cause considerable damage. Pyrethrum or derris is recommended as a substitute for the arsenicals in the control of these pests, using the same dosages as given for cabbage worms.

Melon Worm and Pickle Worm

The indications are that the melon worm and the pickle worm may be controlled satisfactorily on squash in the coastal areas of North and South Carolina and probably elsewhere when the returns from the crop will justify the expense involved, by dusting with a derris-sulphur mixture containing from 1 to 1.5 percent of rotenone. In instances of light to moderate infestation the 1-percent or even 0.5-percent strength rotenone dust should be sufficient if it is applied early and regularly. Where

the infestation is heavy the 1.5-percent dust should be used. While sulphur seems to be the most effective diluent for derris powder for use in melon worm and pickle worm control on squash, this material may cause slight injury to the foliage of this crop. The addition of from 10 to 25 percent of tobacco dust, clay, or talc to the the derris-sulphur mixture will improve its dusting qualities.

The treatments should be begun when the worms first appear on the leaf buds of the squash plant, which may be within a week or 10 days after the plants appear above ground, and continued at 7-day intervals as long as the worms are present or the crop is being harvested. The rate of application will depend upon the size of the plants and should range from 15 to 25 pounds per acre. Extreme care should be exercised to see that the growing tips of the plants are well covered with the dust, as the worms feed extensively on the young leaf buds before tunneling into the fruit, stem, and vines.

Pyrethrum powder has also proved of some value in the control of these pests. The pyrethrum powder should be used in a mixture with clay or talc and sulphur, using equal parts of the pyrethrum and the diluent.

Cryolite, mixed with clay and sulphur in the ratio of 1 pound of cryolite to 1 pound of clay and 2 pounds of sulphur, may be used to advantage in early treatments. In order to avoid danger of poisonous residues on the market product, treatment with this material should not be made after the fruit has begun to set.

Calcium arsenate has not proved satisfactory as a poison for the melon worm or pickle worm.

A bellows type duster is more satisfactory for the treatment of the squash crop than the rotary type because of the method of planting and the necessity of applying the material directly to the growing tips of the plant. In the case of crops producing extensive vines, a duster of the rotary type may be more satisfactory.

Pepper Weevil

While the pepper weevil can be controlled by treating the crop at regular intervals with undiluted calcium arsenate, this method is not to be recommended unless the residue can be adequately removed by washing. Then, too, the regular treatment of the crop with calcium arsenate may result in heavy infestations of plant lice which are capable of causing more crop loss than pepper weevil infestations.

For conditions which obtain in California, cultural control is recommended. This involves complete destruction of pepper plants after harvest, and also the clean-up of nightshade plants in the vicinity of pepper fields, the nightshade being a favorite winter host of the pepper weevil. The pepper fields should be plowed at least by January 1, and all nightshade plants destroyed by the 10th of January. This gives a

period between the destruction of the winter host plants and the planting of the seed bed in excess of the time that pepper weevils are able to live on other than their normal host plants. No experiments have been conducted on the control of the pepper weevil in New Mexico or Texas, and no recommendations are made for the control of this pest in these two areas.

Vegetable Weevil

The vegetable weevil is an important pest of vegetable crops in Alabama, Arkansas, California, Florida, Georgia, Louisiana, Mississippi, and Texas. It is also known as a pest in Tennessee and South Carolina. The following methods are recommended for its control:

(1) Cultivation during the fall and winter period when the prepupae and pupae of the weevil are in the ground.

(2) Poisoned baits scattered lightly between rows and on headlands as soon as the first damage by the newly emerged adults is noticed in the spring. The bait that has been most effective consists of 1 pound of sodium fluoride, 15 pounds of wheat bran, 8 pounds of freshly chopped turnips or carrots, and sufficient water to form a mash. Apply late in the afternoon to prevent excessive drying out of the bait.

(3) Crop rotation where possible, to avoid building up infestations through continuous cropping with favorite host plants.

(4) The treatment of crop remnants with arsenicals after the crop is harvested is advocated as a means of reducing weevil population.

(5) Field sanitation. All rubbish and weeds where the insect may find shelter during inactive periods should be cleaned up.

Mexican Bean Beetle

Derris powder sprays and cryolite sprays (either natural or synthetic) have given equal, if not better, control of the Mexican bean beetle than has magnesium arsenate, in the latest tests conducted.

Sprays. - Derris powder having a rotenone content of 4 percent should be used at a dosage of 2 or $2\frac{1}{2}$ pounds in 50 gallons of water, or at the rate of 2 or $2\frac{1}{2}$ ounces in 3 gallons, which gives a rotenone content of approximately 0.02 and 0.025 percent, respectively, in the spray. In Ohio during 1934, under conditions of severe infestation, derris powder of a rotenone content of 4.4 percent gave good control when used at a dosage of $1\frac{1}{2}$ pounds in 50 gallons of water. Derris powder of a different rotenone content may be used in proportion to that content so as to make a spray containing 0.02 or 0.025 percent of rotenone. The derris powder should be wetted thoroughly in a small quantity of water before it is added to the bulk of the water in the sprayer. The results to date indicate that no sticker or spreader is necessary for the use of derris root powder in water on beans.

Cryolite, either natural or synthetic, should be used at a dosage of 3 pounds in 50 gallons of water, or at the rate of 3 ounces in 3 gallons.

Magnesium arsenate at the rate of 2 pounds in 50 gallons of water is still the most economical insecticide now known for the control of the bean beetle. However, in view of the fact that recently a brand of this material has appeared on the market that severely injured bean foliage, and since recent experiments indicate that better results and greater yields may be obtained by using derris or cryolite, these two materials are recommended in preference to magnesium arsenate. In sections where derris or cryolite is not available, however, magnesium arsenate can be used profitably if a standard brand can be obtained which is known to have given satisfactory results in the past.

Dusts. - Derris dusts of a rotenone content of 0.5 to 0.75 percent, either commercial or home-mixed, may be used with fairly satisfactory results when applied at the rate of 20 to 25 pounds to the acre per application. In the case of home-mixed dusts, either talc, tobacco dust, infusorial earth, or inert clay may be used as a diluent in the same proportions as for cabbage worms, but recent experiments have indicated that talc is the most satisfactory.

Cryolite used as an undiluted dust has given unsatisfactory results, but when used with fine dusting sulphur, wheat flour, talc, or tobacco dust (60 pounds of cryolite to 40 pounds of the diluent) good results were obtained at times, while at other times the results were not so satisfactory. In general, derris dust mixtures have given better results than cryolite, at lower costs, since the more dilute cryolite dusts are not satisfactory.

Sprays are recommended in preference to dusts, since spraying will give better control and longer protection. Growers who prefer to dust or are not equipped to spray will, however, obtain fairly satisfactory results with the dust mixtures.

Except in arid regions, plant injury often results from the use of calcium arsenate mixtures on beans. Lead arsenate should never be used on bean foliage because serious injury and reductions in yields often result from its use, even with bordeaux mixture.

The beans should be sprayed or dusted when adults are found in the field or when egg masses become numerous on the underside of the leaves. One to three, sometimes four, applications are required, depending on the abundance of the insect. The beans must be treated on the underside of the leaves, and care should be taken that the spraying or dusting is done thoroughly.

Caution. - In case cryolite or magnesium arsenate is used, treatments on snap beans should stop when the pods begin to form.

Cultural control. - The destruction of crop remnants after harvest is as important as thorough spraying or dusting. Plow under all plant remnants at least 6 inches deep.

Strawberry Weevil

The hibernation habits of the strawberry weevil in North Carolina are such that the destruction of the weevil by burning over its hibernating areas is a most effective means of reducing losses from attacks of this pest. This burning is necessary only over areas within 100 feet of the strawberry field, as observations have shown that 97 percent of the weevils hibernate within 100 feet of the cultivated areas. The burning should be carried on in the winter and not in the spring, and every precaution should be taken to prevent such fire from getting out of control.

When the burning method can not be applied, satisfactory control of the strawberry weevil may be obtained by dusting with a mixture consisting of 1 pound of calcium arsenate and 5 pounds of sulphur. The first application should be made as soon as the weevil appears in the field. The rate of application will range from 10 to 30 pounds per acre per application, depending upon the density of the strawberry planting. Ordinarily two applications are sufficient to protect the early fruit. All applications of poison dusts should be discontinued at least three weeks prior to the ripening of the first berries, because, where a long bearing season obtains, the treatment with an arsenical poison after this period may result in harmful residues on the ripened berries. In preliminary tests, both derris and pyrethrum powder, applied as dusts, have shown promising results in controlling this insect.

Tobacco Insects

Although tobacco is not a food, it would appear that arsenical or other poisonous residues on tobacco may be harmful to the consumer, and therefore every precaution should be taken to keep the residues from insecticides on tobacco at a minimum.

Tobacco hornworms. - Tobacco hornworms can be controlled by dusting with a mixture of 1 part of paris green and 4 parts of lime. Application should be at a rate of from 4 to 6 pounds of the mixture per acre, per application, depending upon the size and type of the tobacco. Special care should be observed in the manipulation of the crank duster in order to obtain a good coverage of the crop, while at the same time keeping the rate of application as low as possible.

Cultural and other controls for hornworms: Fall plowing is effective in reducing the number of overwintering pupae of the hornworm. Hand-picking of the worms, where the acreage is limited, can be practiced to advantage, especially with low-priced labor.

Considerable progress has been made in an attempt to control tobacco hornworm moths by means of a special poisoned bait, consisting of tartar emetic, which acts as a stomach poison, in a sugar solution. Amyl salicylate is used as an attractant to the moth in conjunction with the poisoned sugar solution. Consult the Bureau of Entomology and Plant Quarantine for further particulars.

Flea beetles. - Barium fluosilicate is an efficient flea beetle insecticide. Undiluted it may be used at the rate of one-half pound per 100 square yards of tobacco plant bed. For larger transplanted tobacco, 3 to 5 pounds per acre are required. Derris diluted with tobacco dust is equally effective as a control for flea beetles in plant beds when the mixture contains 2 percent of rotenone and is applied at the rate of 1 pound of the dust mixture per 100 square yards of plant bed. Approximately 15 pounds per acre of the dust containing 1 percent of rotenone will control the flea beetle on tobacco in the field.

Clean-up Measures as an Aid to Control

Emphasis should be placed on the thorough cleaning up of crop remnants after harvest. It has been observed, in the southern producing areas particularly, that fields of harvested cabbage and similar crops serve as a source of infestation to new plantings.

Appendix

In regard to the relative insecticidal value of derris and cube the following is quoted from an article entitled "Recent Advances in the Knowledge of Derris and Cube", by R. C. Roark of this Bureau, in "Soap", p. 99, Vol. XI, No. 2, February 1935.

"Relative Insecticidal Value of Derris and Cube: No data concerning exact comparisons of the toxicity of derris and cube have been published. It appears pretty well established that, for a given rotenone content, derris contains, in general, larger quantities of other extractives than does cube, and since these extractives are toxic, the derris will in general be the more toxic. Some unpublished work by H. A. Jones, F. L. Campbell, and W. N. Sullivan indicates that if both the rotenone content and the total extractive content of derris and cube are nearly equal, there will be very little, if any, difference in toxicity. As this indication is based on a comparison of only two pairs of samples, no general conclusions can be drawn as yet."

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